LITTLE BLUE BOOK NO. 796
Edited by E. Haldeman-Julius

Life Among the Butterflies

Vance Randolph, B. Sc., A.M.

Drawings by Peter Quinn

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CHAPTER 1

BOOKS ABOUT BUTTERFLIES

Many ancient and mediaeval writers dealt with butterflies, but the first descriptions of American species are found in the works of Linnaeus, the great Swedish naturalist who wrote about 1750, and invented the system upon which all modern classification is based. Pictures of several American butterflies were published in 1759 by Charles Clerck, who had studied with Linnaeus.

Johann Christian Fabricius, a professor at the University of Kiel, published a few more descriptions in 1796, and Peter Cramer, at about the same time, brought out four large volumes on the butterflies of Asia, Africa, and the Americas. Most of these early books were written in Latin, and are now so rare and expensive that few American students have ever seen them.

Jacob Hübner published his great volumes on exotic butterflies in the early part of the nineteenth century. This work was written in German, and contained more than six hundred colored plates, but a good copy now costs about eight hundred dollars, and is of very little use anyway.

In 1797 Sir James Edward Smith brought out his two-volume work on *The Natural History of*

the Rarer Lepiodopterous Insects of Georgia, the first books ever devoted exclusively to North American species. This work is valuable chiefly because it contains some drawings by John Abbot, an Englishman who had actually lived in Georgia and studied moths and butterflies at first hand. Some of Abbot's pictures were later used in another work on American lepidoptera by Dr. J. A. Boisduval of Paris, and Major J. L. LeConte of New York, who wrote in French about 1833. The books of both Smith and Boisduval are now practically unobtainable.

In 1841 the Biological Survey Commission of Massachusetts published a report on injurious insects by Dr. Thaddeus William Harris, which described many New England butterflies. It is now out of print, the last edition appearing in 1862.

The Rev. John G. Harris brought together a deal of information from the works of other writers, and made a few minor observations of his own; his compilation was published by the Smithsonian Institution about 1860.

In 1868 William H. Edwards, an engineer who lived in Coalburg, West Virginia, brought out the first volume of his famous work, *The Butterflies of North America*—probably the best book on the subject ever written. Edwards laboriously worked out the life-histories of many species, and illustrated the work by careful drawings and paintings of his own. Two more volumes appeared later, the last one published in 1897. *The Butterflies of North America* is a magnificent piece of work, produced under all

sorts of handicaps, and will always be a classic to American students of the subject.

In 1886 Dr. Samuel Hubbard Scudder published his *Butterflies of New England* in three volumes; this monograph is superbly illustrated, and compares very favorably even with the epoch-making work of Edwards. The works of Edwards and Scudder are probably the best books on butterflies ever written in any language, and must always remain as monuments of American industry and scholarship. Because of the excessive cost of reproducing the colored plates, however, they are both rather expensive; Scudder's work retailed at ninety dollars, while Edward's three volumes never sold for less than a hundred and fifty, and even this price, according to Dr. W. J. Holland, was below the cost of manufacture.

The Butterflies of the Eastern United States, by G. H. French, appeared about 1886. It is a good little book, and is still in common use, but the illustrations are few and unsatisfactory.

In 1891 C. J. Maynard published a *Manual of North American Butterflies* with ten colored plates; the plates are very poor indeed, and the text not much better.

In 1893 Dr. Samuel Hubbard Scudder, the author of the three great volumes on the New England species, brought out a little book called *The Life of a Butterfly*. It is a brief and popular account of the life-history of *Anosia plexippus*, the Monarch or Milkweed butterfly, which is common everywhere. Dr. Scudder's *Brief Guide to the Commoner Butterflies of the Northern United States and Canada* also appeared in 1893—a very useful little book.

In 1898 Dr. W. J. Holland, Director of the Carnegie Museum at Pittsburgh, published his famous *Butterfly Book*, in which he described more than five hundred species, accompanying each description with a sketch of the life-history and habits in all cases where these details were known. The magnificent colored photograph plates are quite equal for all practical purposes to the hand-colored drawings of Edwards and Scudder, and enable the veriest tyro to classify any of the commoner butterflies simply by comparing them with the pictures. Besides the detailed description of each species there is a great deal of miscellaneous information of interest to the general reader. Because of the new process of reproducing photographs in colors the book sold very cheaply—never more than four or five dollars—and has done more to arouse a popular interest in butterflies than all other works together. Many of the elementary books since 1898 are indebted to Holland's book, and the present booklet is no exception.

In 1905 William Greenwood Wright of San Francisco, published a book called *West Coast Butterflies*. This work is illustrated with colored plates nearly as good as Holland's, and is indispensable to those interested in California species.

George B. Longstaff's *Butterfly-Hunting in Many Lands* appeared in 1912. The book itself is of no great interest to North Americans, as Longstaff spent only two weeks here, and came no farther south than Montreal. Still, his chapter of *Bionomic Notes* deals with butter-

flies in general and is well worth reading. The best part of the book, however, is the appendix, which contains E. A. Elliott's translations of Fritz Muller's famous papers on scent-producing organs in butterflies. The most important of these had never been published except in some obscure Portuguese journals, practically inaccessible to the American student.

In 1916, encouraged by the success of his *Butterfly Book*, Dr. Holland prepared a pocket manual called the *Butterfly Guide*, with colored figures representing some two hundred and fifty species.

In 1917 there appeared Clarence M. Weed's *Butterflies Worth Knowing*, with thirty-two plates in color. This is one of the best of the smaller popular books, and contains a great deal of valuable modern material, but is not to be compared with Holland's work.

No important popular books on butterflies have appeared in recent years. The best single work for the general reader is still Holland's *Butterfly Book;* those living west of the Rockies should have Wright's *West Coast Butterflies* also.

CHAPTER II

THE BUTTERFLY'S BODY

The body of a butterfly, like that of any other insect, is divided by constrictions into three parts: the head, the thorax, and the abdomen. The head carries the eyes, antennae. and mouth parts; the thorax bears the legs and wings; and the abdomen the sexual appendages.

THE HEAD, EYES, AND MOUTH PARTS

The *head* is globular, usually a little flattened from front to rear. Two large *compound eyes* are located at the sides of the head, and the face or front consists largely of a plate called the *clypeus*. Above the clypeus and between the eyes are the *antennae* or feelers, which are believed to be the organs of hearing, smell, and touch. Below the clypeus is the *labrum* or upper lip, and the rudimentary *mandibles;* just below these are the two *maxillae*, which unite to form a tube called the *proboscis*, used in sucking nectar out of flowers. When not in use the proboscis is coiled up like a watch-spring between the two three-jointed *labial palpi*. The *labium* or lower lip is very small in butterflies.

THE THORAX, WINGS AND LEGS

The *thorax* is composed of three segments, the front part or prothorax. the middle part

or mesothorax, and the hind part or metathorax. The *prothorax* bears the front legs; the *mesothorax* the second pair of legs and the fore wings; the *metathorax* carries the third pair of legs and the hind wings. The under side of the thorax is called the *pectus* or breast. The large muscles which operate the legs and wings are contained in the thorax. One pair of *spiracles* or breathing-holes is found in the prothorax; the other seven pairs are located in the abdominal segments.

The butterfly has four *wings*, which are the largest and most conspicuous part of the insect. The wings consist of membranes stretched over horny tubes called veins; in the newly emerged insect the veins contain both blood and air, but the veins of the adult contain air only. The colors of the wing are due to minute *scales* which cover the membranes in an overlapping fashion like shingles on a roof. The scales vary considerably in size and form as well as in color, and the males of some species bear specialized scales known as *androconia*, which produce odors attractive to the females. The third of the wing nearest the body is the *base;* the middle part of the wing is the *median* or *discal* area; the outer portion is called the *limbal* area. The front edge is the *costal margin;* the outer edge is the *external margin;* the posterior edge is known as the *inner margin.* The angle of the outer and inner margins of the front wings is called the outer angle, and the corresponding angle of the hind wings is the inner or anal angle. The outmost tip of the front wing is called the *apex.*

The fore wing has three simple veins: the *costal*, the *radial*, and the *submedian*. There are also two branching veins, the *median* and the *subcostal*. The median vein has three branches or nervules, while the subcostal usually has four or five. The hind wing has five simple veins: the *costal*, *subcostal*, *upper radial*, *lower radial*, *submedian*, and *internal*. The costal vein in the hind wing usually has a short ascending spur called the *precostal* vein but it is classed as a simple vein none the less. The median vein has three nervules, as in the fore wing. In both fore and hind wings, between the subcostal and median veins, there is an area called the *cell*, which is often closed or partially closed on the outer side by three *discocellular veins*, designated as upper, middle, and lower.

Each of the six *legs* is divided into five parts. The section nearest the body is the *coxa*, which is attached to the ring-like *trachanter*. Next beyond the trachanter is the *femur*, then the *tibia*, and finally the *tarsus* or foot bearing the tarsal claws, which are used in clinging to various objects when the butterfly is at rest. In some species the fore legs are small and quite useless, a fact which is used in classification.

THE ABDOMEN

The *abdomen* is composed of ten segments; the first seven bear *spiracles* or breathing-holes (completely hidden by scales, however) and the last two segments are modified to form external sexual appendages. In the male there is a pair of *claspers* for holding the female during copu-

lation; in the female there is only a short and simple *ovipositor*.

THE DIGESTIVE APPARATUS

The *alimentary canal*, the principal part of the digestive apparatus, is a tube extending through the entire body from the end of the proboscis to the anal opening. Just above the proboscis is a *bulb*, which is enlarged by the contraction of muscles attached to the hard parts of the head. When the bulb is expanded nectar may be sucked up through the proboscis; then the valve at the end of the proboscis is closed, and the bulb contracted again. By this means the liquid is forced back into the *esophagus* or gullet, and hence into the *crop*. Just behind the crop is the *stomach*, and just behind the stomach is the *small intestine*. From the small intestine the part of the liquid not absorbed flows into the *large intestine*. which is divided into a front part or *colon*, and a rear and lower part called the *rectum*. From the rectum the fecal matter passes out of the body through the *anal opening*.

THE CIRCULATORY SYSTEM

The *circulatory system* consists essentially of a single blood vessel, running the entire length of the body in about the position occupied by the spinal column in the higher animals. This tube is open at the rear, and has valves opening inward all along its sides. In the thorax there is a pulsating enlargement which serves as a simple *heart*. The *blood* is a colorless liquid which percolates about through the en-

tire body cavity, not being confined to any particular arteries or veins. It is ultimately collected into the dorsal blood vessel, and the pulsating heart keeps it moving, so that it absorbs food from the stomach and intestines, and distributes it to the various parts of the body.

THE RESPIRATORY TRACT

Insects have no lungs, and the blood does not carry oxygen about as in the higher animals; air is drawn into the body and brought into direct and immediate contact with the tissues. In the butterfly there are eight pairs of *spiracles* or breathing-holes—seven pairs in the ab-

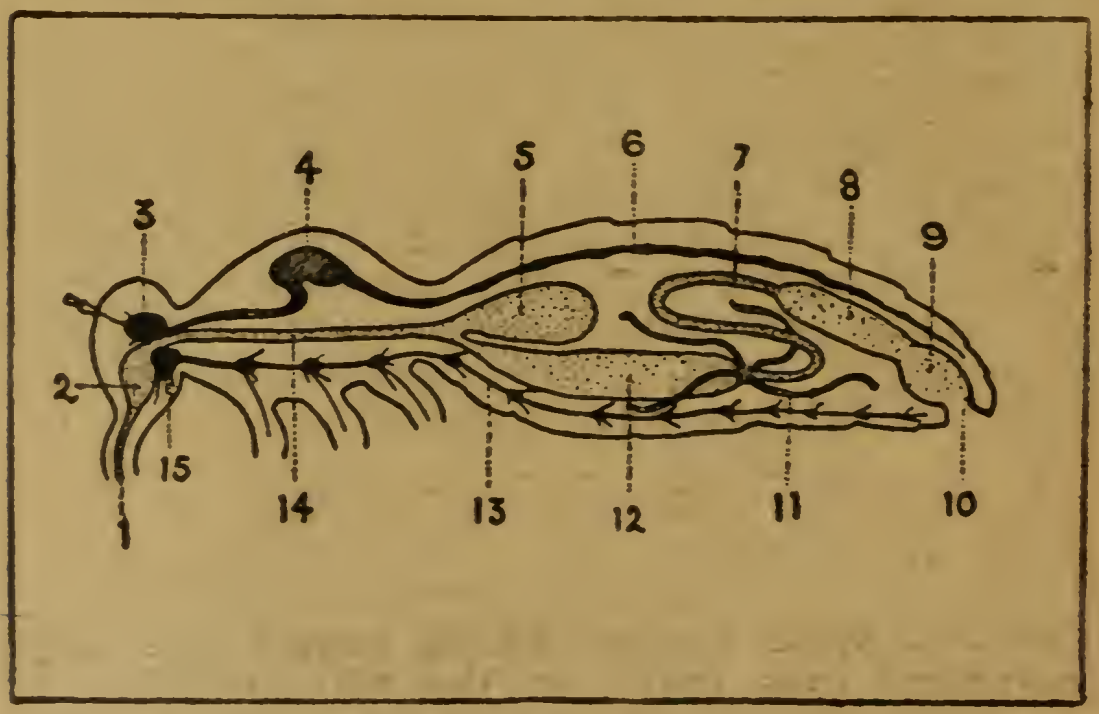

Fig. I.—Diagram showing internal structure. 1, proboscis; 2, bulb; 3, brain; 4, heart; 5, crop; 6, dorsal blood vessel; 7, small intestine; 8, colon; 9, rectum, 10, anal opening; 11, Malpighian tubule; 12, stomach; 13, ventral nerve cord; 14, esophagus; 15, subesophageal ganglion.

domen and one in the prothorax. These spiracles are connected with large *air-sacs* reaching from one end of the body to the other, each air-sac being provided with minute branching tubes called *tracheae*, which carry air directly to the various tissues of the body. The carbon dioxide produced in the respiratory changes passes out through the spiracles, the transfer of gases being produced largely by movements of the abdominal muscles.

THE EXCRETORY ORGANS

The abdomen of the butterfly contains a number of slender *Malphighian tubules*, in contact with the blood contained in the various cavities. These tubules extract waste matter from the blood, functioning just as kidneys do in the higher animals. The butterfly has no bladder or urethra, however; the Malpighian tubules empty into the small intestine, and the urine passes out of the body with the fecal matter.

THE NERVOUS SYSTEM

The nervous system consists of the brain, the subesophageal ganglion, and the ventral nerve cord, together with branches of these structures. The *brain* is a large mass of nerve tissue in the head just above the esophagus. The two *optic nerves* which supply the large compound eyes make up the principal part of the brain, being much larger and more complicated than the *cerebrum*, which is supposed to be the organ of sensation.

The *subesophageal* ganglion is a sort of second brain lying just below the esophagus; it

gives off nerves which supply the mouth parts and control the mechanism of feeding. The *ventral nerve cord* runs back from the sub-esophageal ganglion and traverses almost the entire length of the body, being analogous to the spinal cord of the vertebrates. It bears three *ganglia* in the thoracic region which give off nerves to the legs, wings, and thoracic muscles. Other ganglia, located in the abdomen, have many branching nerves which are distributed to the abdominal muscles and the viscera.

THE REPRODUCTIVE ORGANS

The *ovaries* in the female butterfly are sometimes so large as to crowd the other organs in the abdominal cavity. They communicate by means of tubes called *oviducts* with the *copulatory* apparatus at the end of the abdomen. The *testes* of the male butterfly are usually combined into a single organ; they discharge the *seminal fluid* into the *vas deferens*, whence it is conducted to a sort of pouch near the penultimate segment of the abdomen. In copulation the ends of the male and female abdomens are locked together by certain clasping appendages, and the seminal fluid of the male is forced into the body of the female, where it meets and fertilizes the eggs as they descend from the ovaries.

CHAPTER III

BUTTERFLY METAMORPHOSIS

Some insects, grasshoppers for example, pass through an *incomplete metamorphosis;* that is, the young grasshopper is very much like its parents except as regards size. This is the same sort of development found among birds, reptiles, and other vertebrates. The egg of a butterfly, however, does not hatch into a miniature replica of its parents, but into an altogether different sort of creature, which must pass through a *complete metamorphosis* before it becomes a butterfly. To put the matter briefly, there are four distinct stages in the life of a butterfly: the egg, the caterpillar, the chrysalis, and the imago, or butterfly proper.

THE FIRST STAGE OR EGG

Female butterflies are equipped with organs called ovaries which produce ova, and male butterflies have testes which produce sperm. By an act called copulation (in which the male and female abdomens are locked together by appropriate appendages) the sperm of the male is introduced into the body of the female. A single spermatozoon fuses with each ovum, and the result is a fertilized egg. The female deposits the egg upon a green leaf, and as a rule each species is limited to one or two particular kinds of plants. Butterfly eggs are small, but always large enough to be seen with the naked

eye, and they vary widely in shape and color as well as in size.

THE SECOND OR LARVAL STAGE

Most butterfly eggs hatch within a week or two, producing worm-like larvae called *caterpillars*, which differ in appearance according to the species, but whose general characteristics are well known. The principal business of a caterpillar is to eat; no sooner has it emerged from the egg than it devours the egg-shell, and then sets to work on the leaves of the food plant. Its growth is so rapid that the outer skin must soon be shed, and this shedding process is known as moulting. Most caterpillars moult about four times. The caterpillar stage

Fig. II.—The Viceroy (*Basilarchia disippus*), an example of the family Nymphalidae, or four-footed butterflies. This is the butterfly that mimics the Monarch; see section on Protective Mimicry. A, egg; B, caterpillar; C, chrysalis; D, imago.

usually lasts only a month or so, but there are a few species which hibernate and spend the winter as caterpillars.

THE THIRD OR PUPAL STAGE

When the caterpillar is fully grown it spins a little silken button on some solid object, hangs itself up by the tail, and undergoes a final moult. When the old skin peels off this time it reveals, not a caterpillar with a bright new skin, but a different sort of creature altogether. The apparently lifeless pupa or *chrysalis* shows some of the characteristics of a butterfly, but the wings and legs are folded up, the antennae are cemented fast against the body, and the whole structure covered by a horny, tight-fitting sheath. This state of affairs usually lasts only three or four weeks, but some butterflies, particularly in temperate climates, pass the winter in the pupal state.

THE FOURTH STAGE OR IMAGO

When the chrysalis stage is over the outer skin bursts open about the head, and the *imago* —the butterfly proper—crawls out. The newly emerged butterfly is a sorry-looking specimen; the wings are very small and flaccid, and it can do no more than cling to some convenient support, usually the empty skin of the chrysalis. After a while, however, the body juices flow out into the wings, which expand and harden, and in a few hours the young butterfly is flitting from flower to flower with its fellows.

Ordinarily the imago does not live long—

often only a few days. Just as the caterpillar's sole business is to eat, the mature butterfly has only one important function, and that is reproduction. It speedily finds a mate (that's what its wings are for), contributes its quota of ova or sperm to produce another generation of caterpillars, and its ephemeral existence as a butterfly is over.

CHAPTER IV

THE CASE OF THE RED SILVERWING

Having dealt briefly with the transformations of butterflies in general, it may be well to examine more closely into those of a single representative species. For this purpose I have chosen *Dione vanillae*, known as the Red Silverwing, and have described each stage and transition in considerable detail. The following paragraphs are extracts from the daily records of a study I made in southern Kansas, the northern limit of *vanillae's* usual range.

OVIPOSITION

"One of the females, alighting upon the upper side of a leaf within ten inches of my face, suddenly elevated the forward part of the body, brought the wings together vertically, curved the abdomen slightly forward, and drew its tip slowly across the surface of the leaf for a distance of approximately 12 mm. Remaining quiet for an instant, it lifted the abdomen, showing an egg firmly attached to the leaf. The eggs are laid singly, usually in the upper middle of the leaf. I have never seen more than one upon the same leaf."

THE EGG

"The egg measures about 1.12 mm. in height and .7 mm. in diameter at the widest part, barrel-shaped, with fourteen vertical ribs. A

brilliant yellow at first, it assumes after about thirty-six hours a reddish-brown color. A few hours later an irregular, whitish broken ring, not quite circling the egg, appears about one-third of the distance from the top. When within an hour or so of hatching the shell becomes very thin and transparent and reflects the light with a sort of frosted-glass effect. The large black head of the larva inside gives the upper one-third of the egg a black, metallic appearance, while the yellowish body may be seen curled up in the lower part. The incubation period seems to vary greatly with the temperature, from forty-seven hours to seven days."

THE EMERGENCE OF THE CATERPILLAR

"At 2:15 p. m. the larva was clearly visible through the shell. Slight bodily movements were noted, then the very large, shining black head was thrust out at a point on one side of the egg, just below the top. The entire structure rocked and swayed slowly back and forth, inclining toward the side from which the head projected.

"At 2:19 the larva emerged very slowly, head first. The head and the final segment appeared very large. The entire length was about 1.5 mm. The body yellowish red; prolegs and caudal segment lemon yellow; the head, legs and spines black. The latter bear no visible branches, and appear as stiff, black hairs, each growing out of a slight black protuberance.

"The beautiful eggshell remains erect, the

form being unchanged. There is a ragged hole in it, but it is scarcely noticeable, and appears hardly large enough for the egress of the caterpillar."

THE CATERPILLAR

"The newly emerged larva does not venture far from the eggshell and does not move about much for the first five or six hours. It sometimes devours the shell, but this is not usually the case. At the age of six hours it appears darker, and the black spots from which the hairlike spines protrude have become more conspicuous. Has not eaten any of the leaf, and has increased in size very little if at all."

"At the age of twenty-seven hours the larva attains a length of 2.3 mm. and has eaten several small holes in the center of a large leaf, gnawing through the leaf to the transparent epidermis on the opposite side, which is left intact. Usually works from the upper side, but by no means invariably."

"These smaller larvae seem to be always attached to the leaf with silk, although the threads are very few and fine. More mature larvae feed differently; they grip the petiole with the prolegs, and eat from the edge inward and forward, swinging the head toward the midrib, with practically no lateral motion."

"The caterpillar is cylindrical and bears six rows of black, branching spines, twelve in each row. As regards color, there are besides the reddish, newly hatched creature described above, two well-defined types: the orange-drab and the

drab-orange. In the first the body appears orange with three narrow drab stripes, and a very narrow lateral line just above the prolegs. In the second the drab markings become very much more prominent, so that the body now appears drab with four narrow orange stripes. The narrow drab dorsal line of the younger caterpillar becomes very conspicuous in the mature larva, separating the dorsal surface into two distinct orange areas. As the orange-drab type seems to embrace all of the smaller larvae, and as all those about to pupate belong to the drab-orange type, I have assumed that the color change is a matter of maturity."

MOULTING

"1:30 a. m.—Larva about 21 mm., inactive and very dark, extended on lower side of leaf, front of body high, head bent, holding with third, fourth and anal prolegs. A few silk threads lie flat on leaf near caudal end of body. After some little rippling of muscle (no violent motion) the skin of the body separates from that of the head. The former is very tight; slowly, segment by segment, it is skinned backward until finally it is left, a crumpled, prickly black ball about 4 mm. in diameter, fastened to the leaf by the aforementioned silk. Meanwhile the head covering, which is all of a piece and bears two large spines, slips forward until it appears to be held in the mandibles as a hat might be held between the teeth. After a moment it falls to the ground. The caterpillar now appears somewhat short and a trifle thickened. The

head, legs and prolegs are yellow, the body orange. The spines are only half size, blunt, yellow and semi-transparent. The branches appear as black hairs lying flat along the sides of the spines."

"11:33 a. m.—The spines have now attained practically their normal size, springing out with astonishing rapidity. They are still blunt, yellow and semi-transparent, but the black branches have reached normal size and assumed their proper position. The two head spines, which were curled backward, have taken on the usual angle. The head, body and prolegs now appear orange rather than yellow, the head being lightest. The drab dorsal stripe has appeared, but is very narrow. The row of depressions, one in the dorsal center of each segment, is much more conspicuous than usual."

"11:50 a. m.—Appears quite normal again, except that the spines are not quite as black, showing grayish toward the tips. The black frontal markings appear. Caterpillar rests motionless."

"12:10 p. m.—Turns about and begins to devour the cast-off skin. With the lens I watched it begin at the tip of one of the big spines and consume it clear to the root, apparently in about three mouthfuls. The head covering is never eaten."

"12:30 p. m.—Skin practically consumed. Larva rests motionless, a few of the surplus spines resting beneath the head and thorax."

PUPATION

"10:00 a. m.—Caterpillar, 37 mm. long, leaves

food plant and begins to wander restlessly about.

"1:00 p. m.—Extended motionless, clinging to under side of window frame.

"2:30 p. m.—Same position.

"3:30 p. m.—Begins to lay a sparse, ragged network of very fine threads flat to the surface, covering a space of perhaps an inch square. These threads become thinner toward the periphery of the net, where they are hardly visible without a lens.

"4:00 p. m.—Spins a little white silk button in the center of the network. The head moves slowly out horizontally in all directions from the button about one-half inch, swinging always back to the center. The body is fully extended, the abdomen being away from the button.

"4:30 p. m.—Interrupted the button-making to raise high the caudal third of the body, spreading the anal appendages apart several times. When a pellet of excrement appeared, the caterpillar turned about and pulled it out of the anal opening with the mandibles, holding it thus a moment before allowing it to fall to the floor.

"4:45 p. m.—Resting, body extended, clasping the button with the third prolegs.

6:00 p. m.—Fastened to the button. The body is extended horizontally, clinging to the under surface of the window frame with the prolegs; head drawn back, legs not touching the surface.

"8:00 p. m.—Hanging from the button. The body is thickened a trifle and shortened to 31

mm. Color much lighter; hangs motionless except for very slight movements of the legs and prolegs."

"9:00 a. m.—No change.

"10:00 a. m.—The brilliant colors have practically disappeared, leaving the body a pearl-gray color, against which the black spines show up with startling distinctness. Movements slight and infrequent. The dorsal thorax is now the lightest part of the body.

"11:00 a. m.—Begins to wriggle a little.

"11:10 a. m.—I note that the spines appear closer together at the caudal end of the body; then see that the skin has split down the back and that the light-colored head of the chrysalis is protruding. By a series of vigorous wrigglings the skin is slowly forced up to where the tip of the abdomen is attached to the button. Then comes the violent struggle which finally loosens the skin, which hangs for a moment against the ventral abdomen, then falls to the floor. The entire moult is complete in less than five minutes."

THE CHRYSALIS

"When the chrysalis first appears it is nearly cylindrical; no dorsal depression, no ventral bulge. The head is bent forward, and the whole thing has a compact, slug-like appearance. An hour or so later the head is no longer bent, and bears two double projections, set wide apart; the wing cases are bulging and prominent; on the dorsal side, opposite the middle of the wing covers, is a U-shaped depression; there are projections on the third,

fifth, sixth, and seventh abdominal segments, those on the third being the largest. At first the head, thorax and wing covers are translucent and nearly white; the abdomen is a little darker and bears a ventral bluish stripe on the fourth, fifth and sixth segments. The four pairs of dorsal protuberances are amber-colored.

"An hour later the head and thorax darken somewhat, and opaque whitish veins appear in the wing covers. Distinct black lines mark the outer borders of the fore wings, and a black V-shaped mark shows the position of the larger of the three discal spots.

"Another hour and the translucent appearance is gone, the abdomen and the dorsal thorax become much darker, the wing covers grayish tan, while the bluish ventral stripe turns gray or white.

"From this time forward the chrysalis does not change appreciably in form or color (although the latter varies greatly) until about twenty-four hours before the emergence of the butterfly, when the entire body becomes very dark.

"The average length of the chrysalis is 28 mm., and the white ventral stripe is usually the most conspicuous marking. After the butterfly has emerged the color variations of the chrysalis still persist in the empty shells, some being much darker than others.

"Not infrequently the cast skin of the larva is found attached to the anal portion of the chrysalis. This skin is black excepting the head, which is gray, and the black branching

spines loom large because of the contraction of the empty skin.

"Sometimes the chrysalids turn bright yellow; these are usually infested by parasites. I have opened many of these pupae, but have never found the parasitic larva itself; the pupae and adults I have often taken, the latter being a small (2.3 mm.), green hymenopterous insect which I have not as yet had the opportunity to classify. Some ten or a dozen of these insects emerge from a small round hole, usually in the wing cover, in early August."

PUPAL MOVEMENTS

"The chrysalis seems unable to bend the body toward the back or toward the wing covers; sidewise, however, it can turn until the body is extended nearly parallel to the horizontal surface from which it is suspended. Six chrysalids which hung in a north window in September, 1919, and which I observed for fourteen days, were noted to be invariably and unanimously pointed inward (toward the warm room, that is) every morning. During the warmer part of the day there was no uniformity in position. Six specimens—fourteen days; it appears to be more, perhaps, than mere coincidence. The pupal sensibility to light and temperature stimulii should be worth investigation."

THE APPEARANCE OF THE BUTTERFLY

"Two or three weeks after pupation (the period varies with the temperature, from eight

days in August to twenty-seven in November) the chrysalis turns nearly black, and a diagonal fissure appears on either side, extending from the back of the head down along the antenna cases, nearly to the middle ventrum.

"About twelve hours later, after some little wriggling, the ventral triangle formed by the covering of the head, antennae and mouth parts falls open trap-door fashion, the antennae covers serving as hinges and the flexing point being about one-third of the distance up the wing covers from the abdomen. There is also a dorsal cleavage following the medial dorsum to the first abdominal segment, then the outline of the wing covers to a point half way to the end of the antenna covers. The crumpled-winged imago wriggles out and mounts the empty shell, to which it clings by the four hinder limbs, turning the entire body back and forth as if mounted on a pivot. In each of these turns the body describes an arc of nearly 90 degrees, the body being held stiff. The angle of the body is about 45 degrees from the vertical, the head being uppermost. The proboscis is usually partially unrolled. In five or six hours the soft, wrinkled wings spread and harden, and the insect is able to fly. A thin, transparent liquid, and sometimes a thick, reddish substance, are voided by the newly emerged butterfly."

CHAPTER V

THE CLASSIFICATION OF BUTTERFLIES

In every science it is necessary to manipulate a large number of related facts, and this cannot be done unless the data are arranged in some systematic and orderly fashion. In order to make use of the facts about butterflies, one must know something of the relation of one butterfly to another, and the relation of butterflies in general to the rest of the animal kingdom.

SUBKINGDOMS, CLASSES, ORDERS, AND SUBORDERS

Members of the animal kingdom which have no spinal column, but only an external skeleton composed of horny rings, are assigned to the subkingdom *Arthropoda*. Arthropods which have six legs are grouped together in the class *Insecta*. Insects with scales on their wings are assigned to the order called *Lepidoptera*. This order is divided into two suborders, the *Rhopalocera* or butterflies and the *Heterocera* or moths. Butterflies fly in the daytime, and have slender antennae with club-like knobs at the ends; moths are usually nocturnal or crepuscular, and their antennae are not knobbed, but are thread-like, feather-like, or hooked at the extremity.

THE FOUR FAMILIES

The suborder Rhopalocera is divided into four families: the *Nymphalidae*, the *Lycaenidae*, the *Papilionidae*, and the *Hesperidae*.

The *Nymphalidae* or four-footed butterflies make up the largest family; the first pair of legs are much smaller than the others, and are quite useless for walking. Most of the Nymphalidae are large or medium-sized butterflies. The caterpillars are usually provided with spines or fleshy protuberances, and the chrysalids are always suspended by the tail.

The *Lycaenidae* or gossamer-wings are the bright little butterflies known as "blues," "hair-streaks," and "coppers." The males do not use the first pair of legs in walking, but the females do. The caterpillars are small and usually slug-shaped, and the chrysalids are held closely attached to some object by a girdle of silk.

The *Papilionidae* is the family of the swallowtails and allied forms. Both sexes use all six feet in walking. The butterflies are usually large or medium-sized; many of the caterpillars produce disagreeable odors; the chrysalids are suspended by the tail and provided with a girdle of silk, but not drawn up to the surface to which they are attached, as in the case of the *Lycaenidae*.

The *Hesperids* or skippers are small butterflies with thick, moth-like bodies and a peculiar manner of flight. Both sexes have six walking feet. The caterpillars are smooth and

thin-necked, with large globular heads. The chrysalids are usually enclosed in a flimsy cocoon of leaves fastened together with a few silk threads.

SUBFAMILIES, GENERA, AND SPECIES

Each one of these four families is divided into several subfamilies; each subfamily is divided into several genera, and each genus is divided into several species, all of these divisions being based on an increasing anatomical similarity. Thus the common Milkweed Butterfly belongs to the class *Insecta*, the order *Lepidoptera*, the suborder *Rhopalocera*, the family *Nymphalidae*, the subfamily *Euploeinae*, the genus *Anosia*, and the species *Plexippus*.

THE VALUE OF SCIENTIFIC NOMENCLATURE

One may well ask why we do not simply say "milkweed butterfly" and have done with it, but this term refers merely to the fact that the caterpillar feeds upon a certain plant, while *Anosia plexippus* places the specimen definitely in the scientific scheme of things, and designates important structural distinctions which have nothing to do with milkweeds. The average American is prone to call any insect a "bug" or "moth-miller" or some such unenlightening name, so that many butterflies have no common English name at all, while others have many different names which vary widely in different parts of the country. Besides, the Greek and Latin names are understood by scientists in all countries, and are less liable to

corruption than terms taken from the modern languages.

There are difficulties enough in the scientific nomenclature, without complicating matters by the introduction of popular names. It is a fixed rule in science that the first man to discover and describe a species has the right to name it, and that whatever name he chooses shall be used by everybody forever, but scientists are only human after all, and are always anxious to discover new species and name them after their friends or sweethearts. It often happens that a single species is described independently by several authors, each of which applies a name of his own devising; in this case the first is the real name, and the others are called synonyms.

In writing about butterflies it is not customary to spell out the generic name; one does not write *Dione vanillae*, but merely *D. vanillae*. It is usual also to add the name of the man who first named the species, so that the name becomes *D. vanillae*, Linnaeus, or *D. vanillae*, Linn. In conversation one may omit the name of the genus altogether, and refer to the butterfly simply as *Vanillae*. It is well to remember that scientific Latin in this country is pronounced in the insular fashion—that is, the words are pronounced as if they were English.

VARIETIES

Sometimes the individuals of a species differ in different parts of the country; these different forms are called *varieties*, and are

designated by a varietal name added to the generic and specific names. *Papilio turnus*, Linn. is a large yellow swallowtail, but in the southern part of its range some of the females are black. The black female was formerly regarded as a distinct species, and Linnaeus named it *Papilio glaucus*, but when it was reared from eggs laid by a yellow female it was recognized as a variety, and is now known as *Papilio turnus*, Linn., var. *glaucus*.

CHAPTER VI

THE FOUR FAMILIES

As we said in the chapter on Classification, American butterflies fall naturally into four great groups called families: the *Nymphalidae* or Four-footed family, the *Lycaenidae* or Gossamer-winged family, the *Papilionidae* or Swallowtail family, and the *Hesperidae* or Skipper family.

THE FOUR-FOOTED BUTTERFLIES

The largest family of butterflies in America is the *Nymphalidae*, and its members are called four-footed butterflies because the front legs are so small as to be useless, leaving only four walking feet. Most of the butterflies are large or medium-sized, the caterpillars are usually provided with spines or fleshy protuberances, and the chrysalids are always suspended by the tail. The family is divided into five subfamilies; the *Euploeinae*, the *Heliconiinae*, the *Nymphalinae*, the *Satyrinae*, and the *Libytheinae*.

THE EUPLOEINAE

So far as the great majority of readers are concerned, this subfamily includes but one species—*Anosia plexippus*, the familiar Monarch or Milkweed butterfly, which is common every summer in every state in the Union. The main

color of the wings is bright reddish brown, but the edges are black, and there are some white spots in the black area, particularly in the fore wings. The pale green eggs are laid upon the milkweed, and soon hatch into little black and white caterpillars. The mature caterpillar is greenish yellow with black bands, and each end of the body bears a pair of slender black "horns" or *filaments*. The stout chrysalis is green with golden markings. This butterfly has a bitter taste, and so is not molested by birds or insectivorous mammals. For this reason *Anosia plexippus* has become very abundant and spread over a vast territory. Other

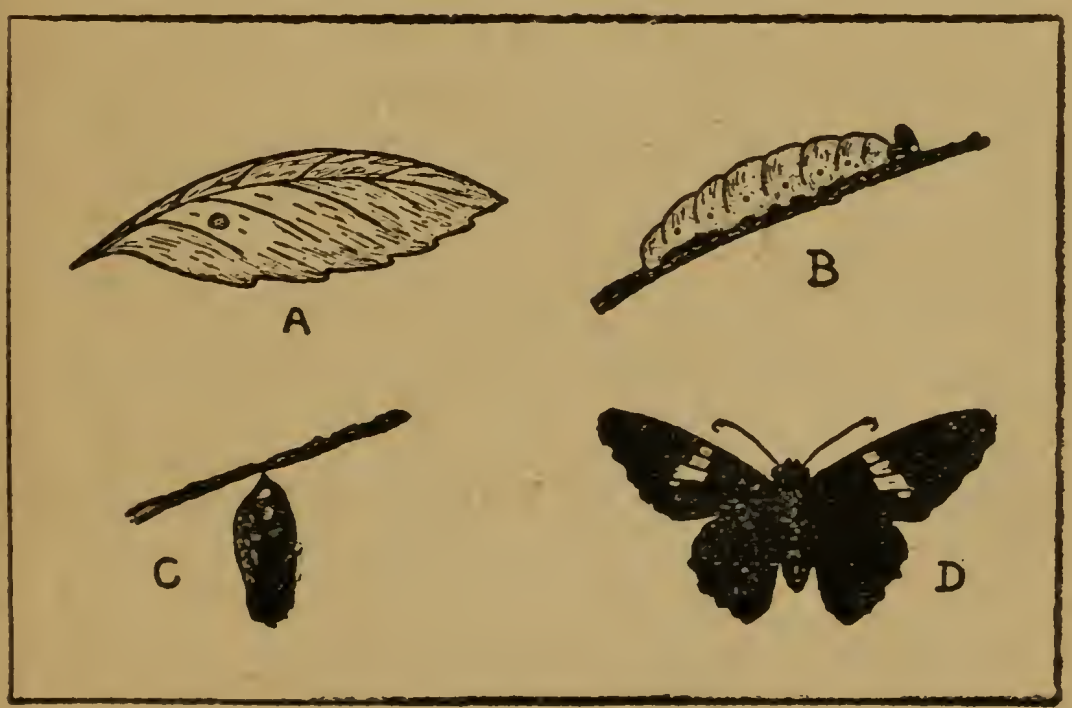

Fig. III.—The Silver-Spotted Skipper (*Epargyreus tityrus*), a typical Hesperid. A, egg; B, mature caterpillar; C, pupa or chrysalis; D, imago.

butterflies which happen to resemble it share in this protection even though they have no disagreeable flavor, and this has given rise to the phenomena of *mimicry*, which is discussed elsewhere in this book. Another interesting thing about the Monarch is the fact that it does not hibernate in any stage; the eggs, caterpillars, and chrysalids die when the cold weather overtakes them, while the adults gather in great swarms and migrate southward, where they breed continuously throughout the winter. With the advent of warm weather the young southern Monarchs come north, deposit their eggs on northern milkweed, and the cycle begins again.

THE HELICONIANS

This is a tropical subfamily, and has only one representative within the borders of the United States. *Heliconius charitonius*, the Zebra butterfly, is a slender, long-winged, black-and-yellow species common along the roadsides of southern Florida. This butterfly has such an evil taste and odor that no known animal will eat it. The eggs are deposited upon the passion-flower vine; the young larva is hairy, but the mature caterpillar is provided with a great number of branching spines. The chrysalis is dark brown and of an odd shape; it makes a peculiar creaking sound by moving its abdomen. Another interesting fact about this Zebra butterfly is that the males are attracted to female chrysalids, and may be seen hovering about waiting for their mates to emerge.

THE NYMPHALINAE

This is the largest of all the subfamilies, numbering more than a hundred and seventy species in the United States. They are mostly large or of medium size, and include many of the commonest and most conspicuous butterflies we have. One of the most interesting members of this group is *Dione vanillae*, the Red Silverspot. The wings are bright red on the upper surface, with black veins and markings; the under side shows a spangled effect of brown and silver. The wings are unusually long, and the butterfly has a disagreeable odor which protects it from its enemies; these and other facts have led some lepidopterists to class this butterfly with the Heliconians. The eggs are reddish brown in color, and are found on the passion-vine; the caterpillar is marked with orange and drab, and bears six rows of branching spines. The chrysalis has an unusual form due to a pronounced dorsal depression; it is usually a grayish tan in color. *Dione vanillae* is found in the whole southern half of the United States, being especially abundant about New Orleans, and in southern California. W. H. Edwards took a specimen at Coalburg, West Virginia, and it has been reported from as far north as Worcester, Mass.

Grapta interrogationis, the Question Mark butterfly, is common in all parts of the United States except the Pacific coast region. The upper sides of both wings are reddish brown, spotted with dark brown and edged with a faint violet color. The peculiar angular shape

of the fore wings, and the little tails on the hind wings, are the outstanding characteristics of the Question Mark and its relatives. The under side of the wings shows a mottled light brown, like a dead leaf; on the under side of the hind wing is found the silver mark resembling a Greek interrogation point (something like the English semicolon) which gave the butterfly its name. The eggs are deposited on elm trees, hop-vines, and several kinds of nettles. The caterpillar is reddish in color, covered with branching spines. The chrysalis is brown or greenish, with a conspicuous protuberance in the thoracic region.

Vanessa antiopa, the Mourning Cloak butterfly, may be remembered as the first butterfly to be seen in the early Spring. The upper surface of the wings is a rich reddish purple, with a yellow border and a row of blue spots just inside it. The under side is gray, and blends perfectly with the dead twigs upon which the butterfly is accustomed to perch. The eggs are laid in clusters on the elm, willow, and poplar trees; the dark, spiny caterpillars live in small colonies, and spin a sort of web among the leaves of the food-plant. The chrysalid is much like that of the Question Mark butterfly. In the autumn the Mourning Cloak crawls into a hollow tree or under a bit of loose bark and sleeps all through the winter, often flying in the Spring before the snow has melted, and long before the first leaves have appeared.

Junonia coenia, the Peacock butterfly, is a medium-sized butterfly with an expanse of

about two and one-fourth inches. The large eye-spots on both wings give it a characteristic appearance, very different from any other butterfly in this country. It occurs in all parts of the United States, but is somewhat rare in the northern part of its range. The dark green eggs are deposited on various kinds of plantain; the caterpillar is dark and covered with spines; the chrysalis generally light brown, and has a conspicuous depression in the ventral thorax. This butterfly is conspicuous for its pugnacity; it will drive away any other species which chances to approach, and even dart at stones or other objects thrown in the air.

Basilarchia disippus, the Viceroy butterfly, looks very much like *Anosia plexippus* the Monarch, except for a single transverse black band on the hind wings. The eggs are laid upon willow or poplar leaves; the caterpillar has no spines, but there are two club-shaped appendages just back of the head; the chrysalis is light gray with brown spots, and has a fin-like projection on back of the thorax. The Viceroy spends the winter in the larval state. When cold weather sets in the caterpillar anchors a leaf to the twig by means of silken threads, then rolls himself up in the leaf and sleeps until the following Spring.

Chlorippe celtis, the Hackberry butterfly, is smaller than most of the common four-footed butterflies, its expanse being less than two inches. The general color of the wings is gray, but the outer part of the fore wings is black with broken rows of white spots. There

is a little red tinge about an eye-spot in the fore wing, and five such spots are located near the outer edge of the hind wing. The female is slightly larger than the male, and somewhat less pronounced in color. The eggs are deposited in clusters on the hackberry trees; the caterpillar bears a pair of antler-like appendages on its head; the chrysalis is stockily built, with the head deeply notched. The Hackberry butterfly is found in all the Southern States east of the Rockies, and has been reported as far north as southern Pennsylvania. It is double-brooded in the middle west, the last caterpillars hibernate and do not reach maturity until the next year.

THE SATYRINAE

The members of this subfamily are medium-sized, obscurely colored, forest-loving butterflies, conspicuous because of their peculiar manner of flopping about in the grass and low herbage.

Satyrus alope, the Wood-nymph butterfly, is a medium-sized grayish brown species, with a broad yellow band across the fore wing. This yellow area contains two eye-spots, dark with blue centers, and in the male there is a smaller eye-spot in the hind wing also. There is a good deal of regional variation in this species: specimens from the Northwest are often small and dark, with a reddish tinge on the lower side of the wings; while in those from northern New England and eastern Canada the yellow band is very dim, and the eye-spots are only vaguely indicated. The eggs are barrel-shaped,

and are laid upon various kinds of grasses; the caterpillar has two slender diverging anal horns; the chrysalis is green, with a prominent tubercle on the thorax. The Wood-nymph is not a strong flyer, but flits about in a furtive, moth-like fashion; if pursued it will often close the wings and fall like a leaf into the grass. These butterflies are usually single brooded, and pass the winter in the larval state.

THE LIBYTHEINAE

The butterflies of this subfamily are easily recognized by the very long projecting palpi, which have the appearance of a beak or snout. *Libythea bachmanni*, the common Snout-butterfly, is a small, reddish brown species, with three or four white spots near the tip of the fore wing. The eggs are found upon Hackberry leaves; the caterpillar has a small head and two or three enlarged thoracic segments; the chrysalis has a sharply pointed head and a conical abdomen. This species probably spends the winter in the chrysalis condition.

THE GOSSAMER-WINGED BUTTERFLIES

The Lycaenidae is the family of delicate little butterflies known as "blues," "coppers," and "hair-streaks." Metallic blue, red, and grey are the predominating colors, and the "hair-streaks" usually have an orange spot on the hind wings. The males of this family do not use the first pair of legs in walking, but the females walk with all six feet. The caterpillars are small and usually slug-shaped, and

the chrysalids are held closely to some supporting object by a girdle of silk.

THE LYCAENINAE

Lycaena pseudargiolus is the common little blue butterfly found in every part of the United States except the far West. It is extremely subject to seasonal and geographic variations, seven or eight distinct varieties having been described. The wings of some specimens are almost black, others are a very pale blue, while still others combine the blue ground-color with a broad black border. The eggs are laid upon a great variety of plants; the caterpillars are very small and slug-shaped, and usually feed upon flowers instead of leaves. The caterpillar produces a sweet liquid which attracts ants, and it is said that these ants protect the caterpillar from minute parasitic flies which would otherwise destroy it.

Feniseca tarquinus, the Wanderer, is perhaps the most interesting of the so-called copper butterflies. The Wanderer's wings are orange brown, spotted with black on the upper side. It is found all over the eastern half of the United States, extending well into the Mississippi valley. The butterfly is remarkable in that it does not frequent flowers, but flits about colonies of plant-lice, and lives upon the sweet excrement of these insects. The eggs are laid among the plant-lice also, and the caterpillar is carnivorous—the only caterpillar in North America which feeds upon plant-lice instead of plants. The chrysalis is small, brown

in color, and bears a striking resemblance to the face of a miniature monkey.

Thecla melinus, the common Hair-streak, is a dark bluish gray, with a deep orange spot just in front of two tiny tails on the hind wing. It is found all over temperate North America. The turban-shaped eggs are usually deposited on the hop-vine; the caterpillar is a slug-like creature with a small head, which can be extended to a remarkable extent. The brown chrysalis lies close to the surface to which it is attached, being fastened both at the tail and by a slight silken girdle about the middle.

THE SWALLOWTAILS AND THEIR ALLIES

The family *Papilionidae* includes many of the commonest and showiest of our butterflies. The adults of both sexes have six ambulatory feet; the caterpillars are elongate; the chrysalids are attached at the tail and held in place by a silken girdle, but never fastened close to the supporting surface, as the Lycaenids are. The Papilionidae is divided into two subfamilies: the *Pierinae* and the *Papilioninae*.

THE PIERINAE

This is the subfamily of the small and medium-sized butterflies, white and yellow in color, so common about pastures and roadsides. *Pieris rapae*, the cabbage butterfly, is one of the most familiar species. It is a white butterfly, with one or two black dots and tips on the fore wings. The pale yellow eggs are de-

posited on cabbage plants; the smooth green caterpillar eats an enormous amount of sauerkraut material, and turns into a gray or brownish chrysalis. This butterfly was originally a European species; imported through some accident, it appeared in Quebec about 1860. As early as 1868 it was common about New York, and by 1881 had spread to all of the eastern states. In 1886 it was reported from Denver, and has since taken possession of cabbage-fields in every part of the country.

Colias philodice, the Common Yellow, is the butterfly seen swarming about roadside mud-puddles in August and September. The wings are lemon color with black borders, and in the

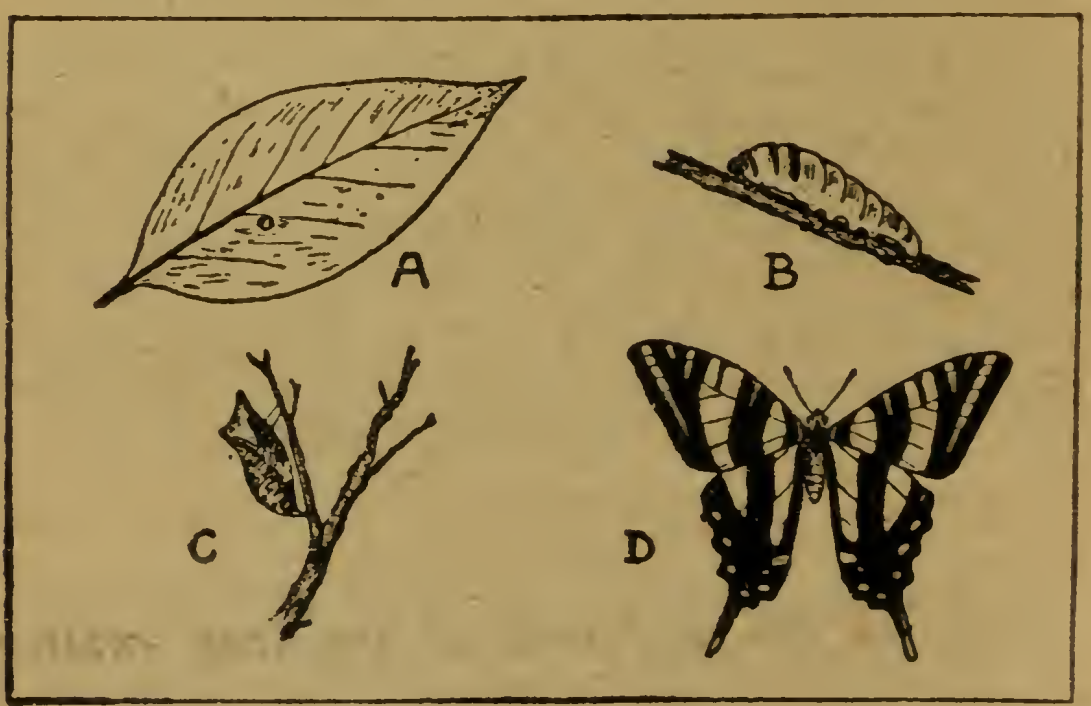

Fig. IV.—The Zebra Swallowtail (*Papilio ajax*). a typical representative of the subfamily Papilioninae. A egg; B, mature larva; C, pupa or chrysalis (note the silken girdle); D, imago or adult.

female the borders are usually broken by several small yellow spots. The yellow or reddish eggs are laid upon various kinds of clover; the slender green caterpillar is exactly the color of the leaves; the chrysalis is usually pale green also. This butterfly is found from New England to Florida, and as far west as the Rocky Mountains.

Terias lisa is another yellow butterfly, much smaller than Colias philodice, rarely expanding more than an inch and a quarter. The wings are lemon yellow with black borders, subject to many minor variations. The caterpillar feeds on clover, but the early stages of this species have never been thoroughly studied, despite the fact that the butterfly is common from the New England states to the Rockies.

Terias mexicana, the Mexican Yellow, is larger than *Terias lisa*, and somewhat paler in color. The black borders or the fore wings are very wide and indented, and the hind wings are pointed. Very little is known of its early stages. It is common in Texas, Arizona, and Southern California, and often strays much farther north. I have myself taken a number of specimens in Kansas.

THE PAPILIONINAE

This is the subfamily of the true swallowtails, the largest and most distinctive of American butterflies. The hind wings are prolonged into two tail-like projections, and are characterized, by the absence of the internal vein. The caterpillars are all provided with peculiar V-

shaped scent-organs called *osmateria;* these organs are thrust out just back of the head when the insect is disturbed, and give off an offensive odor, supposed to discomfit birds and other enemies.

Papilio troilus, the Green-clouded Swallowtail, is velvety black with a row of yellow spots along the margin of the fore wings. The marginal spots on the hind wing are pale green, and the whole outer half of the hind wing is clouded with the same greenish tinge. The female deposits her eggs on sassafras and spicebush leaves; the caterpillar is lead-colored or greenish, with a swollen thorax bearing two large eye-spots, and lives in a nest made of a folded leaf. *Papilio troilus* is common throughout the Atlantic States and in the Mississippi Valley.

Papilio turnus, the Tiger Swallowtail, is the magnificent yellow-and-black species found in practically every part of the United States. In the northern portion of its range the male and female appear very much alike, but in the South there are two distinct types of females. One female is black-and-yellow like its northern sisters; the other is black-and-blue, with no yellow at all except a few small crescents in the outer border of the hind wing. The black female was for a long while considered a distinct species and called *Papilio glaucus*. Later, however, it was discovered that some of the eggs laid by the yellow *turnus* produced the black *glaucus* females, and that, conversely, the eggs of *glaucus* often produced the ordinary yellow-and-black Tiger Swallowtail. The smooth

bluish-green eggs are usually found on the wild cherry leaves; the caterpillar is green, with enlarged thoracic segments bearing two large eye-spots like those of Papilio troilus.

Papilio ajax, the Zebra Swallowtail, is another striking member of this magnificent subfamily. The combination of green and black stripes, the blue and red crescents and the long tails on the hind wings, distinguish *ajax* immediately from any of its splendid fellows. There are at least three slightly different seasonal varieties of this butterfly, due probably to differences in the temperature to which the chrysalids are exposed. The butterfly may often be seen hovering about pawpaw bushes, upon which the eggs are deposited. The mature caterpillar is pea-green with bands of yellow and black; the chrysalis is green or brownish, and the last crop of chrysalids does not produce butterflies until the following Spring. This butterfly ranges from New England south to the Florida Keys, and west to the foot-hills of the Rockies.

Papilio cresphontes, the Giant Swallowtail, is the largest butterfly in this country, measuring nearly six inches from tip to tip. The color is dark brown with bands and blotches of bright yellow, and there is a red-and-blue spot on the inner margin of the hind wings. The under side of both wings is yellow, with narrow dark brown bands. This butterfly is very common in Florida, where the caterpillars—the natives call them orange-dogs—do a great deal of damage to the orange and lemon trees. Each female butterfly is known to lay

a great number of eggs, and it has been suggested that the ravages of the orange-dog may be checked by shooting the butterflies on the wing with miniature shotguns. In recent years the species has extended its range northward, and has become quite common in the Middle West; a number of specimens have been taken in New England, and even in Canada. In the northern part of its territory there are no citrus trees, but the caterpillar feeds well enough upon prickly ash and several kinds of poplars.

THE SKIPPERS

The *Hesperiidae* or Skipper family includes all the large bodied, small-winged, moth-like butterflies, called Skippers because of their jerky, erratic manner of flight. They are mostly small, dull colored butterflies with short, hooked antennae. The caterpillars are recognized by their large heads and small necks, and usually live in nests made of leaves fastened together with silk. The chrysalids are rounded and moth-like, and (unlike all the other families) are usually enclosed in a loose cocoon of silk. The classification of Skippers is a complicated business; the Hesperiidae is the only family in which the beginner will find it difficult to identify his specimens.

Epargyreus tityrus, the Silver-spotted Skipper, is the largest member of the family, with an expanse of about one and three-fourths inches. The general color is dark brown, with yellowish spots; the common name is derived from the silver area on the lower surface of

the hind wing, which shows when the insect is at rest. The caterpillar is yellowish green, with a dark brown head; it feeds upon the leaves of the locust and other leguminous trees. When the caterpillar is mature it leaves its hammock in the locust tree and builds a light silken cocoon upon or near the ground. The Silver-spotted Skipper is found in nearly every part of the United States.

Atalopedes huron, the Sachem Skipper, is a little golden brown species, with an expanse of a little more than an inch. The male has a darker area in the center of the front wing, while in the female the fore wing is marked by several small white spots. When at rest this skipper and its near relatives usually elevate

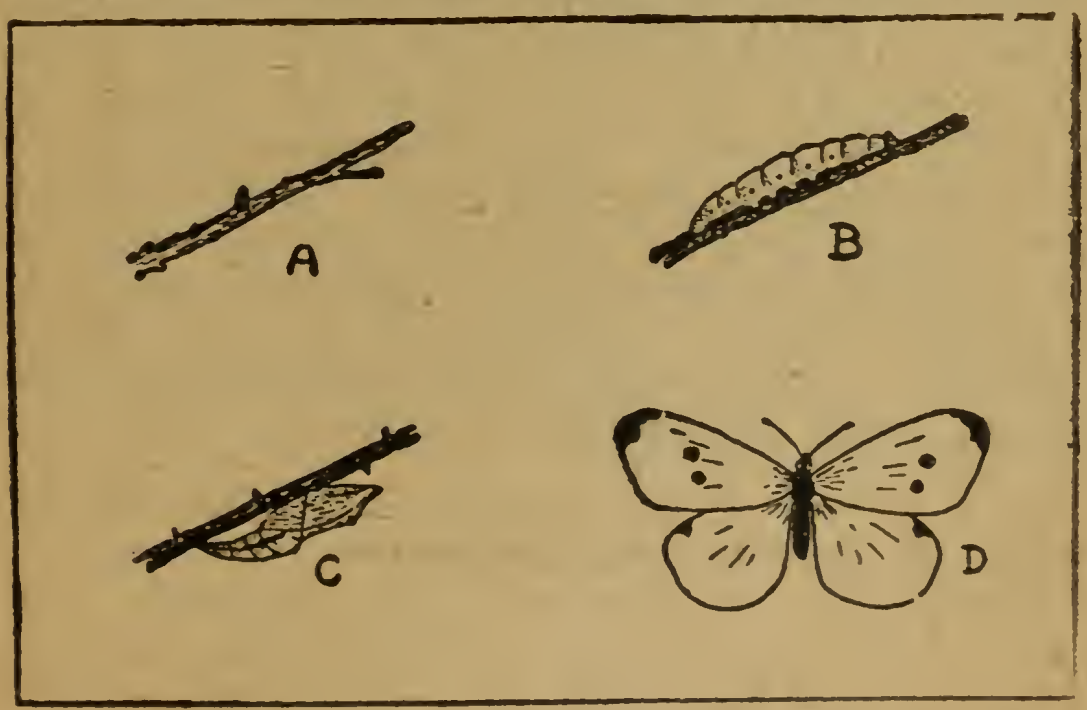

Fig. V.—The Cabbage Butterfly (*Pieris rapae*). This butterfly was brought over from Europe about 1860, and has spread to every part of the United States and Canada. A, egg; B, caterpillar; C, chrysalis; D, imago.

the fore wings and depress the hind wings, an attitude characteristic of this group. The dark, cylindrical caterpillar feeds upon various grasses; the chrysalis is slender, with a little swelling upon the thorax, and the tongue sheath is free as in the pupae of moths. The Sachem is known from New York to Florida, and as far west as eastern Colorado.

Ancyloxipha numitor, the Least Skipper, is the smallest butterfly within our borders, measuring often less than three-fourths of an inch from tip to tip. The slender body and hookless antennae distinguish it from all other skippers. The general color is bright reddish brown, the hind wings being particularly brilliant, and surrounded by a darker border. Its flight is weak and wavering, and it rests often among grasses at the edges of creeks or swamps. The yellow eggs are laid on grasses; the tiny yellow caterpillar has a black head and a body covered with bristles, and lives in a rolled-up blade of grass. The chrysalis is reddish, with small black dots. The Least Skipper is widely distributed everywhere east of the Rocky Mountains.

CHAPTER VII

ENEMIES AND PROTECTION

Butterflies have many enemies. Even the eggs of butterflies are often discovered by tiny, four-winged parasites, which pierce the egg-shell and deposit their own microscopic eggs inside. These eggs produce little grubs, which devour the contents of the butterfly's egg, so that the latter develops into a caterpillar.

The chief enemies of the butterfly tribe, however, are the insectivorous birds, whose summer food often consists largely of caterpillars. Caterpillars are also attacked by wasp-like parasites which deposit their eggs in the victim's skin; when the eggs hatch the parasitic grubs feed upon the flesh of their unwilling host, who usually dies about the time the guests are ready to pupate. One often sees dead or dying caterpillars covered with the white cocoons of these hymenopterous parasites. Certain larger wasps, too, use caterpillars as food for their young. These insects paralyze their prey by stinging it, lay their eggs on the helpless body, and seal it up in a hollow reed, or in a nest of mud. When the wasp larva hatches it finds plenty of living food at hand.

Chrysalids also are eaten by birds and by various carnivorous insects, and are frequently killed by parasitic wasps and flies. Many an amateur butterfly-hunter has been puzzled to

see that some of his chrysalids produce, not beautiful butterflies, but a lot of insignificant little wasps.

Adult butterflies are not much troubled by parasitic insects, but they are eaten by many birds, particularly those of the fly-catcher type, by lizards, and by the larger dragonflies. Spiders kill a few, the great gray robber-flies carry off a butterfly now and then, and frogs and toads take them whenever possible. They are not much attacked by the mammals, but I have seen a chipmunk devour a large *Papilio turnus* with every symptom of satisfaction.

Long ages of struggle with these enemies have developed certain protective devices—not through any supernatural intervention or any conscious activity on the part of the butterflies, but simply by the mechanical process called natural selection. There is a certain degree of variation among all animals, and some of these variations are transmitted to succeeding generations. Now, if certain butterflies happen to vary in such a way that they are protected against their enemies, they survive at the expense of their less fortunate fellows, and such of their offspring as inherit the protective variation also survive, until at last, by a gradual process of elimination, the entire species is protected.

PROTECTIVE COLORATION

One of the commonest of the protective devices is called *protective coloration.* It may be noted that many caterpillars are green, a color

which blends well with that of the leaves upon which they feed, and so protects them in a measure from the prying eyes of their enemies. Such chrysalids as are attached to green leaves or twigs are often green also, but most caterpillars leave the foliage to pupate, and the chrysalids are neutral gray or brown so as to be inconspicuous against a background of bark or dead wood. Many butterflies pass the winter in the chrysalis state, and these cold weather chrysalids are never green, but usually some dull color which harmonizes with the winter landscape.

Another thing to be noted, particularly in caterpillars, is the operation of the so-called *law of counter-shading*, which means simply that the part of the body which gets the most light is usually darkest in color. Some caterpillars habitually feed with their feet downward, and their backs are darker than their bellies; others are accustomed to feed in the opposite position, and the shading tones are reversed. One has only to look at a few living specimens in their native haunts to see the value of this arrangement.

In adult butterflies it may be observed that it is the upper side of the wings which shows the bright colors, while the lower side is much less conspicuous. The flying butterfly is not in much danger anyway, and a display of color can do no great damage, but it might be fatal to the same insect at rest. At rest, however, the wings are usually brought together vertically, so that the highly colored upper side is quite concealed, and only the dull under

surface exposed to view. In some butterflies—*Vanessa antiopa*, for example— the lower surface so nearly resembles the bark upon which the insect is accustomed to rest that it can hardly be distinguished, even when one knows exactly where to look for it.

Some of these protected butterflies illustrate a minor protective phenomenon known as *dazzling* or *eclipsing coloration.* Many observers believe that the sudden change from the bright colors of the flying butterfly to the neutral tints of the same specimen at rest is more confusing to a pursuer than the total absence of brilliant colors. This dazzling and eclipsing effect is particularly noticeable in various species of *Grapta* and *Vanessa.*

Another thing to be remarked is the fact that many butterflies protectively-colored, such as those mentioned above, usually alight on some object similar in color to the lower side of their own wings. These butterflies are accustomed to rest upon the trunks of trees, and almost invariably select one with dark-colored bark, avoiding green or light colored trees such as birches and sycamores. It is not claimed the individual butterfly, after examining the colors of its wings, casts about for a perch to match, but it is quite conceivable that those which were attracted to light-colored bark have been gradually weeded out of the species.

OFFENSIVE ODORS AND TASTES

Besides the method of protective coloration, some caterpillars are protected against birds by sharp spines or hairs; others by peculiar

markings and attitudes said to approximate the appearance of serpents or other dangerous objects. Many butterflies, it has been observed, are protected by still other methods. The common Monarch (*Anosia plexippus*), the Zebra butterfly (*Heliconius charitonius*), and the Red Silverwing (*Dione vanillae*) are very conspicuous butterflies, yet they flutter leisurely about unmolested by birds and other enemies. This protection is due to what Alfred Russell Wallace called "a strong, pungent, semi-aromatic odor, which seems to pervade all the juices of their system."

It has long been known that certain butterflies produced disagreeable odors, but Fritz Müller, working in Brazil as early as 1876, was the first to give the matter any very serious attention. Since Müller's time extensive studies have been made by Colonel Longstaff and Dr. Dixey, two English entomologists, but very little has been done in North America. It is certainly true, however, that the three butterflies mentioned above (and doubtless many others) are possessed of some taste or odor offensive to their enemies.

Dione vanillae is more abundant in South America than in the United States, and was one of the species investigated by Müller, who writes: "The males . . . when seized, open wide the anal valvulae, from the inner side of which there appear two glands yielding a strong and nauseous smell. The females, on the contrary, emit a similar smell from a yellow gland extruded on the dorsum between the last and penultimate segments." Longstaff,

who studied this butterfly in Jamaica, describes it as "a beautiful but ill-smelling Fritillary" and says it smells like cow-dung.

WARNING COLORATION

It has been noticed that many dangerous and distasteful insects are rendered conspicuous by their brilliant colors, and examples of this so-called *warning coloration* are not lacking among the butterflies. The Swallowtail caterpillars, whch produce a very disagreeable odor, are usually marked by two great staring eye-spots on the back of the thorax. Some of the protected butterflies, such as the ill-smelling Zebra and Red Silverwing, are extraordinarily conspicuous by reason of striking color-combinations. Many entomologists believe that these peculiar color-schemes have been developed by protected butterflies as an advertisement of their inedible character. This view is not as popular as it used to be, but there may be something in it; it certainly seems to explain the structure and habits of some of the higher animals—the rattlesnake for example—better than any other hypothesis yet advanced.

PROTECTIVE MIMICRY

There seems to be a tendency among certain insects which are edible and unprotected, to bear a superficial resemblance to inedible or distasteful species. Thus certain harmless flies have developed a remarkable likeness to wasps and bumblebees, although in structure and habits they are really very different. Several

diurnal moths, too, have transparent wings, and yellow bands about the body which give them the appearance of gigantic and singularly ferocious hornets. It is certainly a great advantage for a harmless insect to resemble some dangerous and inedible species, and the whole phenomenon of resemblance has been called *protective mimicry.*

The best example of mimicry in American butterflies is the case of the Monarch (*Anosia plexippus*) and the Viceroy (*Basilarchia disippus*). The Monarch belongs to the subfamily *Euploeinae.* all the members of which are provided with secretions which render them distasteful to birds and predaceous insects. The Monarch advertises its inedibility by its bright brown and black wings, and its leisurely manner of flight. The Viceroy belongs to an altogether different group, the members of which are readily eaten by birds, and which do not resemble the Monarch either in form, coloration, or manner of flight. The Viceroy, however. has gradually developed so remarkable a resemblance to the Monarch that it is difficult to distinguish them at a little distance, although the Viceroy is much the smaller of the two. and has a traverse black band on the hind wing that is lacking in the Monarch. There is no doubt that the Viceroy benefits by this resemblance, as birds (doubtless mistaking it for the inedible Monarch) appear to give it a wide berth.

This novel situation is supposed to have come about as follows: In the remote past the Viceroy was a blue-and-black butterfly like its

relatives, but because of the abiding principle of variation the individuals of the species were not exactly alike—some specimens were lighter than others. For some reason or other these lighter-colored butterflies had a slight advantage in the struggle for existence, and so in time the entire species was of this type, the darker specimens having been exterminated. Finally, some individuals chanced to bear a slight resemblance to distasteful butterflies of the Monarch type, so that birds avoided them, but continued to feed upon their less fortunate relatives. Thus, through a long process of natural selection, the Viceroy has come to resemble the Monarch.

HELIOTROPISM AND LIST

It was long ago observed that plants respond definitely and mechanically to the direction of rays of light; the leaves and flowers of many plants always turn toward the sun, and even follow its daily course, so that the flower which turned to the East in the morning faces due West at sunset. Similar phenomena are now known to occur in animals. Among butterflies a good example is that of the Mourning Cloak (*Vanessa antiopa*). This butterfly, when it alights in the sunlight, almost invariably turns about until its body lies parallel with the rays of light and its head points directly away from the sun. This phenomenon is known as *negative heliotropism*, and a number of plausible explanations of it have been advanced. Probably it is merely another method of blending with the back-

ground, akin to protective coloration. When the Mourning Cloak alights upon the ground. or upon a log, it closes its wings and becomes well-nigh indistinguishable from its surroundings. because the under side of the wings is protectively colored. Now, if the body lies at right angles to the sun's rays, the wings cast a large shadow, much more conspicuous than the butterfly itself, and hence attracting unfriendly eyes to the butterfly. If. however. the body is in line with the rays of light, and the wings brought together vertically. the shadow is insignificant. One has only to pin a few dead butterflies on a smooth neutral background in full sunlight to see the force of this theory. It is very probable, then, that *negative heliotropism* is simply a method of reducing the too-conspicuous shadow to its lowest terms.

Other butterflies reduce the shadow by what is known as *list*, leaning far over to one side like a sail-boat in a storm—hence the name. The best American example of *list* is found in the behavior of the Wood-nymph butterfly (*Satyrus alope*), which is often seen to topple over to one side. presenting the entire wing surface to the source of light, lowering the top-line and thus reducing the shadow.

FEIGNING DEATH

Many insects. particularly beetles, frequently escape their enemies by feigning death. Whether this behavior is an instinctive ruse or a genuine paralysis induced by something akin to fright we do not know, but it is doubtless of considerable value to the insect. Some

butterflies have been known to play 'possum when in a tight place. *Vanessa cardui*, known as the Painted Lady, sometimes closes its wings, folds its legs close to the body, and falls motionless to the ground. Usually it is lost in the weeds or grasses, but even if found and picked up it often allows itself to be handled without any sign of life. Similar behavior has been reported in *Satyrus alope*, the Wood-nymph butterfly,